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Single Crystals of Metal Solid Solutions: A Study

A published report describes the growth of silver-alloy crystals under widely varying conditions of growth rate, temperature gradient, and magnetic field. The role of gravitation and convection on the crystal substructure is analyzed, as well as the influence of magnetic fields applied during crystallization. The study, entitled "Single Crystals of Metal Solid Solutions," indicates that magnetic fields of moderate strength damp out convective currents. Single crystals grown within the field will form with a preferred orientation. Without the presence of the magnetic field, polycrystals having a random orientation are formed.

The report divides the study objectives into four tasks: (1) "Investigation of the Influence of Convection and Crystal Growth," (2) "Investigation of the Influence of Magnetic Fields on Crystal Growth," (3) "Characteristics of Crystals and Analysis of the Effects of Growth Conditions," and (4) "Space Flight Experiment Definition." A summary of the report follows.

Experiments determined the characteristics and effects of convection currents in molten Ag-20Zn alloy in a horizontal boat. Temperature fluctuations, resulting from the convection currents, were monitored at overall longitudinal temperature gradients of 1.5°, 2.5°, 5.5°, 7.5°, 8°, 12°, and 16.5° C/cm in the region of the thermocouples. No significant short-term temperature fluctuations were observed with longitudinal temperature gradients less than 8° C/cm.

Magnetic fields applied in the range of 50 to 4,000 gauss showed that low-to-moderate fields (50 to 250 gauss) decreased the amplitude of convection-current

induced temperature oscillations and damped out some of the complex oscillations, while fields in the range of 300 to 350 gauss appeared to damp out all oscillations caused by turbulent convection. No additional effect was detected when higher magnetic fields (up to 4,000 gauss) were applied.

Several horizontal Bridgman crystal-growth runs were made with and without seeds, both under conditions calculated to produce constitutional supercooling and cellular growth and to give planar interface growth and banding. The single-crystal seed material of the Ag-20Zn alloy had been grown in vertical Bridgman growth runs. The examination of ingots crystallized under conditions calculated to give constitutional supercooling revealed expected cellular growth. The results of electron microprobe analysis of the cellular structure indicated that cell-wall thickness and composition differed from ingot to ingot, presumably due to differences in crystallization rate and melt composition.

Metallographic examination of some ingots, grown under conditions calculated to give planar interface growth (with and without magnetic fields up to 4,000 gauss) revealed no unusual microstructural features. However, distinct changes in macrostructure were found to correlate with the application and removal of the magnetic field. Limited X-ray Laue diffraction analysis, conducted on one of the ingots containing sections grown with and without a magnetic field, indicated that there was a preferred growth direction in both the single-crystal and polycrystalline portions.

(continued overleaf)

Note:

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NASA has decided not to apply for a patent.

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